# JCAT

## Corrosion Performance of AlumiPlate Coated Electrical Connectors with Trivalent Cr Post-Treatment

**January 24, 2007**
**New Orleans Marriott at the Convention Center**
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# Overview

- **Test alternatives to Cadmium Plated electrical connectors.**
- **Alumiplate Inc. provided NAVAIR with electrical connectors to evaluate the coatings for corrosion resistance and conductivity.**

# Connectors Tested

| All Connectors Comply to MIL-DTL-38999 | | | | |
|---|---|---|---|---|
| **Test ID#** | **Material** | **Plating** | **Post-treatment** | **Number** |
| AC3 | AA6061 | Alumiplate | Class III Chromate | 6 |
| AC1 | | | Class 1A Chromate | 6 |
| AT2 | | | 25% TCP-HF | 6 |
| AT5 | | | 50% TCP-HF | 3 |
| CC3 | PEEK | | Class III Chromate | 6 |
| CC1 | | | Class 1A Chromate | 6 |
| CT2 | | | 25% TCP-HF | 6 |
| CT5 | | | 50% TCP-HF | 3 |
| ACd | AA6061 | OD Cadmium | | 3 |
| CCd | PEEK | OD Cadmium | | 1 |
| CPN | PEEK plug | Nickel | | 1 |
| CP3 | PEEK plug | Alumiplate | Class III Chromate | 1 |

- TCP was Metalast TCP-HF
- Amphenol Inc. left out one important process that we had done on all previous Alumiplate coated connector testing. The retaining clip spring behind the coupling nut on the AlumiPlate Inc. coated aluminum connectors is supposed to be coated with a MIL 46010 Dry film Lubricate prior to final assembly.

# Tests Performed

- Corrosion Tests
  - ASTM B117 Salt fog [2000 hrs], half the connectors, removed and photographed at intervals of 1, 2, 5, 7, 8,10, and 12 weeks.
  - ASTM G85 SO2 salt fog [500 hrs], half the connectors, removed and photographed at intervals of 2 days, 1 week, 10 days, 2 weeks, 16 days and 20 days.
  - Corrosion tests (but no durability) per Mil-DTL-38999 4.5.12.2 and Mil-Std-1344A Method 1001.1. Mil-DTL-38999 4.5.12.2 states 1000 hrs for all series, except class C, H, K ,W & Y 500 hrs, and 2000 hrs for series J and M (conductive composite PEEK) in neutral salt fog. NAVAIR tests goes beyond that and add SO2 testing.

# Tests Performed

- Conductivity Tests
  - Connectors were removed from Salt Fog chambers as outlined in the previous slide and measurements taken and recorded.
  - Conductivity tests per Mil-DTL-38999 3.38, 4.5.24 and MIL-STD-1344 Method 3007.

# Corrosion Tests


- ASTM B117 Neutral Salt Fog, half the connectors
- Connectors hung with wax string from the top of the chamber

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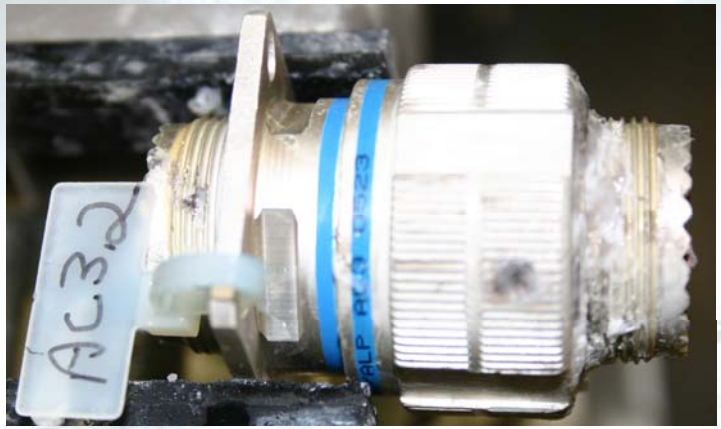
# Corrosion Tests


- ASTM G85 SO2 Acid Salt Fog Test
- Connectors hung from wax string at the top of the Chamber

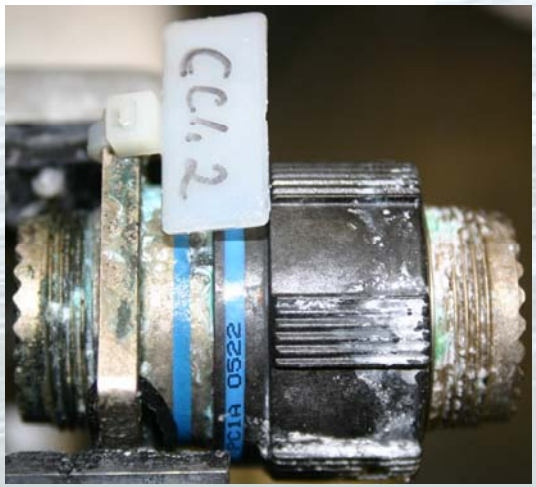
# Corrosion Tests ASTM B117

2000 Hrs


6061 Aluminum Connector W/OD Cadmium Plating




6061 Aluminum W/ Alumiplate coating W/ Class III Chromate




PEEK with Alumiplate coating
Class 1A Chromate


6061 Aluminum with Alumiplate
coating and 50% TCP Dilution

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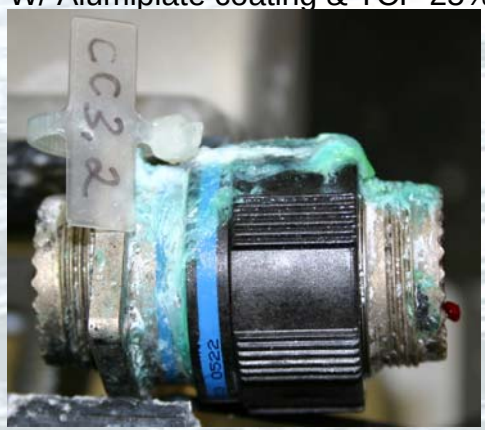
# Corrosion Tests ASTM B117

2000 Hrs


6061 Aluminum W/ Alumiplate coating
coating Class 1A Chromate


PEEK W/ Alumiplate coating & TCP 25% dilution


6061 Alumium W/ Alumiplate Coating
With TCP 25% dilution




PEEK W/ Alumiplate & Class III Chromate

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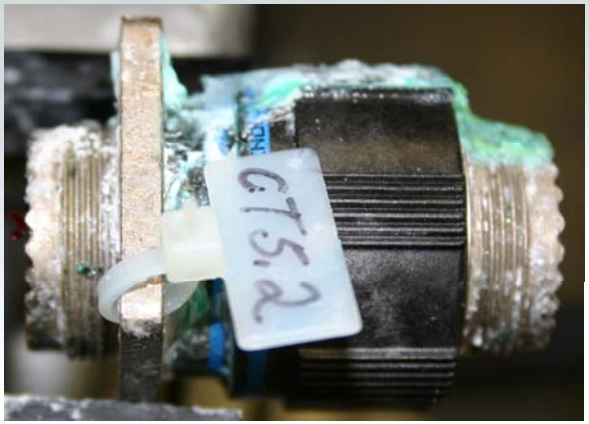
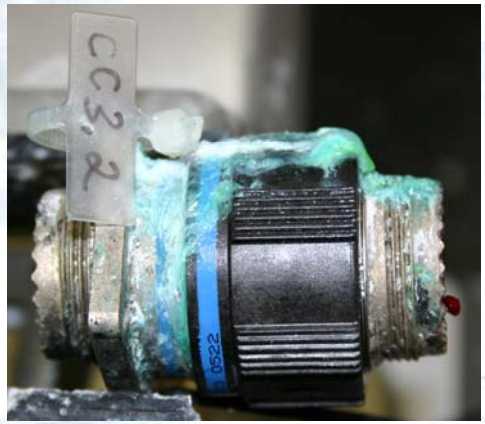
# Corrosion Tests ASTM B117

2000 Hrs




PEEK W/ Alumiplate coating & TCP 50% Dilution




PEEK W/ Alumiplate & Class III Chromate

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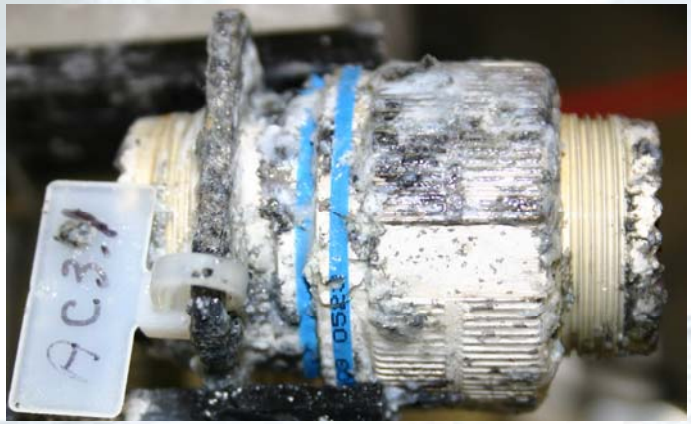
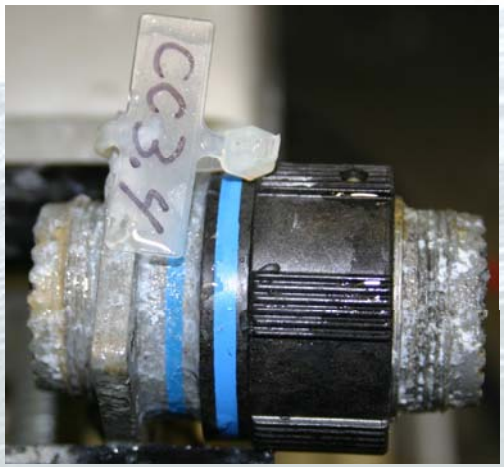
# Corrosion Tests ASTM G85

500 Hrs

Cadmium plated 6061T6 Aluminum



Alumiplate coated 6061-T6 Aluminum with Class III chromate



PEEK W/ Alumiplate & Class III Chromate

PEEK Connector W/ Nickel Coating

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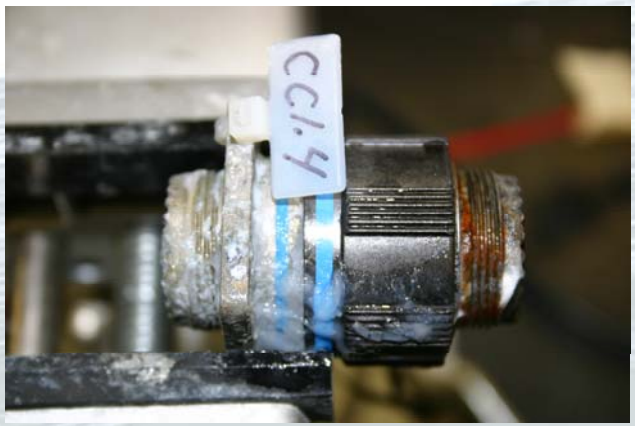
# Corrosion Tests ASTM G85

500 Hrs


PEEK W/ Cadmium Plating


6061 Alumium with Alumiplate coating W/ Class 1A Chromate




PEEK W/ Class 1A Chromate


6061 Aluminum with Alumiplate coating W/ TCP 50% dilution

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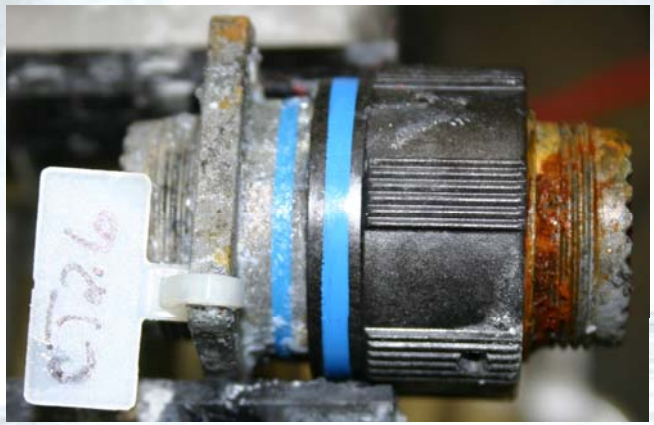
# Corrosion Tests ASTM G85

500 Hrs

6061 Aluminum with OD Cadmium Plating



PEEK W/ Alumiplate coating & TCP 25% dilution

6061 Alumium W/ Alumiplate Coating & 25% TCP dilution

PEEK W/ Alumiplate Coating W/ Class III Chromate

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# Corrosion Tests

- Conclusions
  - All connectors performed equal to or better than Cadmium Plated controls
  - PEEK connectors performed the best with both the Chromate and TCP postreatments
  - Aluminum connectors both the Chromate and TCP post treatments were comparable to the Cadmium controls.

# Conductivity Tests


Test IAW MIL-STD-1344A Method 3007

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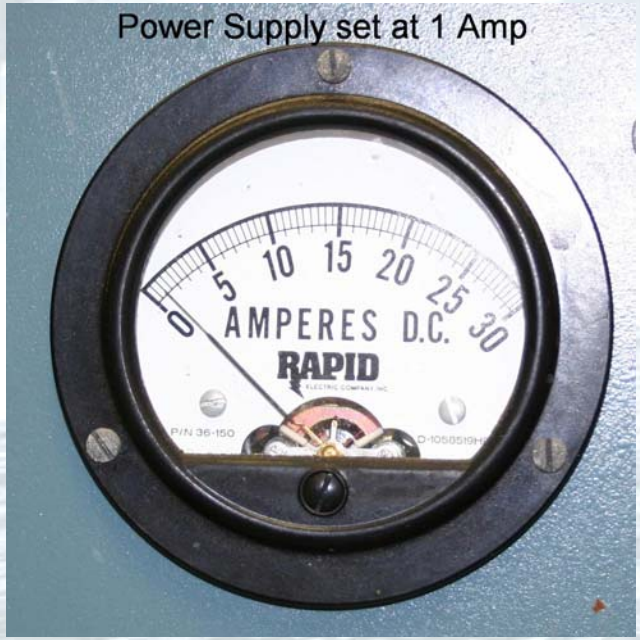
# Conductivity Tests


- Measurements taken from the rear accessory thread on one end and the flange on the other end of the mated pair
- 1 Amp DC at 1.5 volts is applied to the mated pair of connectors
- Measurements taken at the same interval as the corrosion tests
- All results in Millivolts
- Maximum allowed 2.5 millivolts per MIL-DTL-38999K 3.28 for class W, olive drab cadmium plated

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# Conductivity Tests Data ASTM B117

| ID | B117 Conductivity (millivolts DC) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 hrs | 168 hrs | 336 hrs | 840 hrs | 1167 hrs | 1344 hrs | 1680 hrs | 2016 hrs | |
| AC3.1 | 0.154 | 0.505 | 0.309 | 0.185 | 0.558 | 0.673 | 0.123 | 0.778 | AA6061 w/ Alumiplate w/Class III |
| AC3.2 | 0.108 | 3.12 | 0.059 | 0.200 | 0.225 | 0.011 | 0.205 | 0.174 | |
| AC3.3 | 0.099 | 0.089 | 0.275 | 0.146 | 0.205 | 0.253 | 0.749 | 0.281 | |
| AC3.4 | | | | | | | | | |
| AC3.5 | | | | | | | | | |
| AC3.6 | | | | | | | | | |
| AC1.1 | 0.221 | 0.166 | 2.53 | 0.038 | 3.285 | 1.253 | 1.932 | 1.666 | AA6061 w/ Alumiplate w/Class IA |
| AC1.2 | 0.197 | 1.17 | 0.498 | 0.923 | 1.660 | 1.840 | 1.977 | 0.711 | |
| AC1.3 | 0.404 | 3.07 | 15.97 | 1.015 | 0.028 | 157.141 | 195.760 | 56.728 | |
| AC1.4 | | | | | | | | | |
| AC1.5 | | | | | | | | | |
| AC1.6 | | | | | | | | | |
| AT2.1 | 1.14 | 8.59 | 4.133 | 0.208 | 8.149 | 0.033 | 4.389 | 4.544 | AA6061 w/ Alumiplate w/TCP 25% dilution |
| AT2.2 | 0.78 | 4.33 | 3.494 | 10.667 | 11.273 | 12.564 | 28.100 | 15.931 | |
| AT2.3 | 10.95 | missing | missing | missing | missing | missing | missing | missing | |
| AT2.4 | | | | | | | | | |
| AT2.5 | | | | | | | | | |
| AT2.6 | | | | | | | | | |
| AT5.1 | 0.194 | 0.535 | 0.396 | 0.885 | 0.027 | 0.879 | 1.088 | 0.459 | AA6061 w/ Alumiplate w/TCP 50% dilution |
| AT5.2 | | | | | | | | | |
| AT5.3 | | | | | | | | | |
| CC3.1 | 0.507 | 1.19 | 1.126 | 1.454 | 1.476 | 1.304 | 1.364 | 1.529 | PEEK Connector w/Alumiplate w/Class III |
| CC3.2 | 0.572 | 1.03 | 0.89 | 1.382 | 1.421 | 7.685 | 1.291 | 1.272 | |
| CC3.3 | 0.541 | 1.35 | 0.832 | 1.375 | 1.918 | 1.191 | 1.416 | 1.329 | |
| CC3.4 | | | | | | | | | |
| CC3.5 | | | | | | | | | |
| CC3.6 | | | | | | | | | |
| CC1.1 | 0.639 | 3.05 | 0.871 | 1.415 | 1.405 | 1.288 | 3.156 | 1.248 | PEEK Connector w/Alumiplate w/Class IA |
| CC1.2 | 0.652 | 1.75 | 1.386 | 1.342 | 1.586 | 1.763 | 1.414 | 1.444 | |
| CC1.3 | 0.54 | 1.24 | 0.906 | 1.447 | 1.555 | 1.722 | 1.332 | 1.307 | |
| CC1.4 | | | | | | | | | |
| CC1.5 | | | | | | | | | |
| CC1.6 | | | | | | | | | |
| CT2.1 | 0.444 | 0.864 | 1.186 | 2.457 | 1.444 | 1.157 | 1.527 | 0.030 | PEEK Connector w/Alumiplate w/TCP 25% |
| CT2.2 | 0.442 | 1.53 | 0.817 | 1.272 | 1.298 | 1.994 | 1.503 | 1.528 | |
| CT2.3 | 0.603 | 1.693 | 1.076 | 1.538 | 1.383 | 1.796 | 1.284 | 1.548 | |
| CT2.4 | | | | | | | | | PEEK Connector w/Alumiplate w/TCP 25% |
| CT2.5 | 0.506 | 1.14 | 0.855 | 1.636 | 1.314 | 1.330 | 1.278 | 1.213 | |
| CT2.6 | | | | | | | | | |
| CT5.1 | 0.806 | 1.32 | 0.968 | 1.836 | 1.454 | 1.756 | 1.345 | 1.706 | PEEK Connector w/Alumiplate w/TCP 50% |
| CT5.2 | 0.834 | 1.19 | 0.956 | 1.352 | 2.037 | 1.530 | 2.235 | 2.527 | |
| CT5.3 | | | | | | | | | |
| ACd.1 | 0.168 | 1.17 | 0.488 | 0.557 | 0.799 | 0.670 | 0.825 | 0.947 | AA6061 w/OD Cd |
| ACd.2 | | | | | | | | | |
| ACd.3 | | | | | | | | | |
| CCd | | | | | | | | | PEEK w/OD CD |
| CPN | | | | | | | | | |
| CP3 | | | | | | | | | |

Note: Class 1a Chromate not standard, Class III Standard

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# Conductivity Tests Data ASTM G85

| ID | G85 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Conductivity (millivolts DC) | | | | | | |
| | 0 hrs | 48 hrs | 168 hrs | 240 hrs | 336 hrs | 384 hrs | 480 hrs | |
| AC3.1 | | | | | | | | |
| AC3.2 | | | | | | | | |
| AC3.3 | | | | | | | | |
| AC3.4 | 0.075 | 0.231 | 0.425 | 0.294 | 214.439 | 0.037 | 0.614 | AA6061 w/ Alumiplate w/Class III Chromate |
| AC3.5 | 1.120 | 2.251 | 12.890 | 13.580 | 0.078 | 38.410 | 21.870 | |
| AC3.6 | 0.100 | 0.138 | 0.263 | 0.169 | 0.663 | 0.212 | 0.223 | |
| AC1.1 | | | | | | | | |
| AC1.2 | | | | | | | | |
| AC1.3 | | | | | | | | |
| AC1.4 | 0.063 | 0.095 | 0.140 | 0.106 | 0.160 | 0.130 | 0.162 | AA6061 w/ Alumiplate w/Class IA Chromate |
| AC1.5 | 0.123 | 0.214 | 0.328 | 0.351 | 0.200 | 0.564 | 0.532 | |
| AC1.6 | 0.590 | 4.210 | 11.260 | 22.760 | 14.880 | 23.790 | 28.110 | |
| AT2.1 | | | | | | | | |
| AT2.2 | | | | | | | | |
| AT2.3 | | | | | | | | |
| AT2.4 | 0.922 | 52.790 | 98.050 | 56.550 | 302.340 | 152.860 | 87.257 | AA6061 w/ Alumiplate w/TCP 25% dilution |
| AT2.5 | 0.848 | 15.470 | 58.800 | 77.210 | 66.820 | 34.070 | 232.040 | |
| AT2.6 | 1.340 | 18.150 | 47.340 | 66.300 | 4.630 | 19.250 | 10.950 | |
| AT5.1 | | | | | | | | AA6061 w/ Alumiplate w/TCP 50% dilution |
| AT5.2 | 0.393 | 0.888 | 4.230 | 14.240 | 41.620 | 50.060 | 88.620 | |
| AT5.3 | 0.159 | 1.243 | 4.830 | 14.250 | 84.910 | 46.990 | 0.280 | |
| CC3.1 | | | | | | | | |
| CC3.2 | | | | | | | | |
| CC3.3 | | | | | | | | |
| CC3.4 | 0.502 | 0.567 | 0.945 | 1.060 | 0.661 | 0.836 | 1.145 | PEEK Connector w/Alumiplate w/Class III Chromate |
| CC3.5 | 0.456 | 0.141 | 0.950 | 0.735 | 3.666 | 1.350 | 1.164 | |
| CC3.6 | 0.473 | 0.566 | 1.160 | 0.948 | 0.941 | 1.240 | 1.496 | |
| CC1.1 | | | | | | | | |
| CC1.2 | | | | | | | | |
| CC1.3 | | | | | | | | |
| CC1.4 | 0.638 | 0.753 | 1.780 | 0.945 | 1.154 | 1.405 | 1.656 | PEEK Connector w/Alumiplate w/Class IA Chromate |
| CC1.5 | 0.621 | 0.704 | 1.384 | 1.270 | 1.083 | 1.049 | 2.053 | |
| CC1.6 | 0.686 | 1.030 | 1.060 | 1.110 | 1.309 | 1.469 | 1.819 | |
| CT2.1 | | | | | | | | |
| CT2.2 | | | | | | | | |
| CT2.3 | | | | | | | | |
| CT2.4 | 0.508 | 0.748 | 1.530 | 1.390 | 1.070 | 1.795 | 3.430 | PEEK Connector w/Alumiplate w/TCP 25% dilution |
| CT2.5 | | | | | | | | |
| CT2.6 | 0.627 | 0.663 | 1.230 | 0.781 | 1.003 | 1.722 | 1.778 | |
| CT5.1 | | | | | | | | PEEK Connector w/Alumiplate w/TCP 50% dilution |
| CT5.2 | | | | | | | | |
| CT5.3 | 0.800 | 0.670 | 1.260 | 1.340 | 0.855 | 1.580 | 1.409 | |
| ACd.1 | | | | | | | | |
| ACd.2 | 0.199 | 1.066 | 0.797 | 0.384 | 0.368 | 0.444 | 0.513 | AA6061 w/OD Cd |
| ACd.3 | 0.351 | 0.924 | 0.919 | 0.638 | 17.002 | 0.536 | 2.762 | |
| CCd | 0.469 | 1.170 | 13.450 | 39.250 | 129.950 | 140.431 | 42.580 | PEEK w/OD CD |
| CPN | 0.857 | 1.030 | 17.050 | 8.100 | 10.950 | 48.330 | 456.350 | PEEK w/Ni coating |
| CP3 | 0.261 | 1.065 | 37.690 | 4.720 | 19.680 | 8.870 | 13.060 | PEEK w/Alumiplate w/Class III Chromate |

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# Conductivity Tests

- Conclusions
  - ASTM B117 results, all connectors meet applicable requirements of the MIL-DTL-38999 Specification except AA6061 Aluminum w/ Alumiplate coating W/ 25% TCP Post Treatment
  - ASTM G85 results, all connectors passed (2.5 Miliivolts) except AA6061 w/ Alumiplate coating W/ 25% TCP Post Treatment, Note: 6061 Alumiplate coating w/TCP 50% performed similar to cadmium controls
  - PEEK connector plug w/ Ni coating and PEEK connector plug w/Alumiplate coating w/ Class III chromate conversion coating did not pass ASTM G85 salt fog but no ASTM B117 test was performed due to lack of connectors. Not enough data to form a conclusion, however they perform similar to Cadmium Plated controls.

# Conclusions

- All connectors meet applicable requirements of the MIL-DTL-38999 Specification except AA6061 Alumiplate coating w/ TCP 25%
- Failure Criteria for these tests are in line with F-35 criteria that connectors must survive and maintain functionality.
- Recommend TCP only be used at the 50% concentration when used as a post treatment for 6061 Aluminum Alloy connectors
- PEEK connectors performed the best overall

# Questions

## Comments

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